Abstract

In response to the global climate crisis and the accelerating transition toward sustainable energy offshore renewable systems, particularly floating technologies, are gaining strategic importance. Their potential to harness abundant marine resources while minimizing land use conflicts makes them an attractive solution for densely populated and environmentally sensitive regions. However, the marine environment presents unique technical challenges that demand reliable and cost effective design methodologies.

This thesis emphasizes the importance of high-fidelity numerical modeling in the design and validation of floating offshore structures. Through the development of advanced simulation frameworks, it demonstrates how high-fidelity tools can resolve critical aspects of wave structure interaction, such as pressure field distribution, nonlinear kinematics, and mooring dynamics. Strong emphasis is placed on experimental validation to assess model accuracy.

Although high-fidelity simulations are computationally intensive, they provide valuable insights that can enhance lower-order models and support more informed engineering decisions. In this context, the thesis advocates for a multi-fidelity modeling strategy, where high-fidelity results are used not only as benchmarks but also as tools for systematically tuning simplified models and improving the reliability of broader simulation workflows.

This study advances the methodologies and tools available for offshore system analysis and contributes to the development of more robust and efficient renewable energy technologies, enabling their safe and scalable deployment in the marine environment.